Combining Hough Transform and Contour Algorithm for detecting Vehicles' License-Plates

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ABSTRACT

Vehicle license plate (VLP) recognition is an interesting problem that has attracted many computer vision research groups. One of the most important and difficult task of this problem is VLP detecting. It is not only used in VLP recognition systems but also useful to many traffic management systems. Our method is used for the VLP recognition system that deals with Vietnamese VLPs and it can also be applied to other types of VLPs with minor changes.

There are various approaches to this problem, such as texture-based, morphology-based and boundary line-based. In this paper, we present the boundary line-based method that optimizes speed and accuracy by combining the Hough transform and Contour algorithm. The enhancement of applying the Hough transform to contour images is that the much improved speed of the algorithm. In addition, the algorithm can be used on VLP images that have been taken from various distances and have inclined angles between $\pm 30^0$ from the camera. Especially, it can detect plates in images has more than one VLP. The algorithm was evaluated in two image sets with accuracy of about 99% (see 3.3).

1. INTRODUCTION

Our VLP Recognition system was based on the following model:

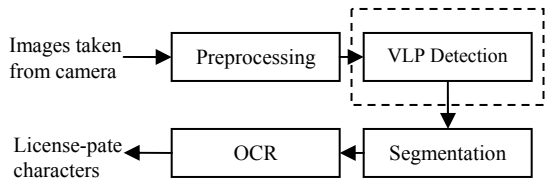


Fig 1. An automatic vehicles' license-plates Recognition system

Detecting VLP is the most important and difficult task in VLP Recognition systems. The VLP detection module receives images which were processed by the preprocessing module – the first input module of this system. The results of this module are sent to the segmentation module. The segmentation module segments plate-images into separate character-images. These character-images are then recognized by the OCR module and the final results are characters and numbers in plate (see Fig 1).

Fig 2. Types of Vietnamese plates: 1 row and 2 rows

Detecting VLP is difficult due to a number of reasons, including the complexity of texture images, the number of contained objects, and the variety of size and the inclined angles of license plates. Moreover, there may be plates with scratchs and plug-in helixes. In this paper, we mainly discuss on the VLP detection module.

2. RELATED WORK

The problem of automatic VLP recognition has been studied since 1990s. The first approach was based on characteristics of boundary lines. The input image was firstly processed to enrich boundary lines' information by an algorithm such as the gradient filter. These images were constantly processed by an algorithm to detect lines. Finally, a couple of 2-parallel lines were considered as a plate-candidate [3][4]. Another approach was the morphology-based one [1]. This approach focuses on properties of plate images such as its brightness, symmetry, angles, etc. By using these properties, this method can detect the similar properties

in a certain image and locate the position of license plate images. The third approach was texture-based one [2]. According to this approach, a VLP was considered as an object with different textures and frames. The texture window frames of different sizes were used to detect plate-candidates. These candidates were passed to a classifier to confirm whether they are plates or not. This approach was commonly used in finding text in image tasks. In addition, there have been a number of other methods related to this problem but focusing on detecting VLP in video data (objects appear in a chain of sequent images)[5][6].

3. THE PROPOSED ALGORITHM

3.1. Preprocessing

Images taken from camera were processed by the preprocessing module. The purpose of this module was to enrich the edge features. This will improve the successful rate of the VLP detection module. The algorithms sequentially used in this module are graying, normalizing and histogram equalization. After having obtained a grey-scale image, we use Sobel filters to extract the edging image, then thresholding the image to a binary one. The resulted images are used as inputs for the VLP detection module.

3.2. Vehicles' License-Plates Detect Algorithm

In order to detect regions of plate-candidate image, we firstly apply contour algorithm for detecting closed boundary objects. A number of candidate evaluation algorithms are applied on contour images obtained from the contour algorithm to separate plate objects.

Fig 3. A successful case of using Contour algorithm only

Failed detection

Fig 4. A failed case of using Contour algorithm only

However, this algorithm has difficulties in processing bad quality images due to scratches, plug-in helixes. In these cases, the contour algorithm produces incomplete closed boundary lines that do not contain correctly the plate-images.

Our second approach was applying Hough transform to the binary image to extract lines from object-images. Then we looked for two parallel lines, whose the contained region is considered plate-candidates. Each candidate is verified by using a number of evaluation algorithms (see 3.2.2). However, the main limitation of this approach is the time required since the Hough transform is applied to a usually great number of pixels. Especially, the larger image is, the slower the algorithm is. The speed of the algorithm may be improved by thinning image before applying the Hough transform. However, the thinning algorithm is also slow. The limitation of processing speed makes this approach unsuitable for real time traffic management systems.

The method we present in this paper is the combination of the two approaches above which produces higher accuracy and faster speed so that it can be applied to real time systems.

3.2.1. Combine Hough Transform and Contour Algorithm for Detecting VLP

Our approach is as follows: from the extracted edging image, we use the contour algorithm to detect closed boundaries of objects. These contour lines are transformed to Hough coordinate to find two interacted parallel lines (one of two parallel lines hold back the other 2-parallel lines and establishes an parallelogram-form object) that are considered as a plate-candidate. Since there are quite few (black) pixels in the contour lines, the transformation these points to Hough coordinate required much less computation. Hence, the speed of the algorithm is improved significantly without the loss of accuracy (see Fig 5).

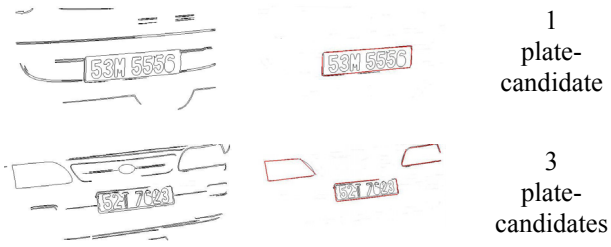


Fig 5. Two case successful case when use combination of Contour algorithm and Hough transformation

However, there may be images that have other objects such as wear glasses, headlights, decorated things, etc. These objects may also have the shape of two interacted 2-parallel lines, and therefore, are also falsely detected as plate-candidates. To reject such incorrect candidates, we implement a module for evaluating whether a candidate is a plate or not.

3.2.2. Plate-Candidates Verification

From the two horizontal lines of a candidate, we can calculate exactly how inclined it was from horizontal coordinate. Then we apply a rotate transformation to adjust it to straight angle. After processed, these straight

binary plate-candidate images were passed to a number of heuristics and algorithms for evaluating.

Our evaluating plate-candidates algorithm based on two main steps, which are taken sequently. The two steps are: evaluating ratio between height and width of candidate, using horizontal crosscuts to count number of cut-objects in candidate.

3.2.2.1. Evaluate ratio between width and height of candidate

In this stage, we check and only select out candidates that have height and width ratio satisfied pre-defined constraint:

$$\text{minWHRatio} < W/H < \text{maxWHRatio}$$

Since there are two main types of Vietnamese plates: 1-row and 2-row (See Fig 2), we have two appropriate constraints for two types.

$3.5 < W/H < 4.5$ with 1-row plate-candidates
$0.8 < W/H < 1.4$ with 2-row plate-candidates

The candidates that satisfied one of two above constraints are selected and passed to the next evaluation.

3.2.2.2. Evaluate by using horizontal crosscuts

In this stage, we use two horizontal cuts and count the number of objects that are cut by these crosscuts. A candidate will be considered as a plate if the number of cut objects in a range that was practical given (see examples in Table 1). This number must be in the approximate range of the number of characters in a VLP, we have two appropriate constraints for two types of Vietnamese plates:

$4 \le N \le 8$ with 1-row plate-candidates
$7 \le N \le 16$ with 2-row plate-candidates

With N is the number of cut-objects.

The candidates that satisfied one of two above constraints are selected as the final result.

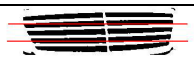
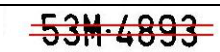
Plate-candidates	Number of objects	Result
	2	Non-plate
	2	Non-plate
	10	Plate
	4	Plate

Table 1. A sample of using horizontal cuts to evaluate plate-candidates

In our work, we implemented two hoziontal cuts at 1/3 and 2/3 of plate-candidate's height. The average of number of cut objects will be calculated. This evaluation help identify the correct plate-candidates.

3.3. Empirical evaluation

The algorithm was evaluated with two sets of Vietnamese vehicles' plates. Images were taken by a Sony DC350 digital camera, with size of 800x600 pixels, in different places and times. The IDE we implemented was Microsoft Visual C++ 6.0, run on HP Workstation X2000 Pentium IV, 1.4 GHz, 512 MB RAM, Windows XP OS.

Image set	Camera position	Light condition	Number of images
A	Airport check-in office. Rotated angles: right, left ~ 30^0	10-12 AM	415
B	Random locations. Rotated angles: right, left ~ 30^0 or straight	Morning or night (with flash light)	390

Table 2. Image sets were used in tests

Evaluating was taken on the two image sets above and showed the following results:

Image set	A	B	A+B
Number of images	415	390	805
Corrects	412	383	795
Errors	3	7	10
Correct accuracy	99.27%	98.2%	98.76%
Error accuracy	0.73%	1.8%	1.24%
Avg speed to process one image	0.65s	0.65s	0.65s

Table 3. Test results

In the evaluation, the algorithm were proved to be successful on a number of difficult cases with bad quality plates (Fig 7), or multiple plates in the same image, or different types of vehicles such as motorbike plates, car plates or truck plates (Fig 8).

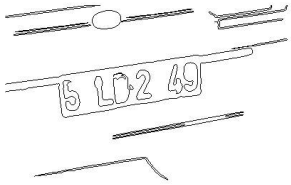


Fig 7. A successful case with a bad quality plate

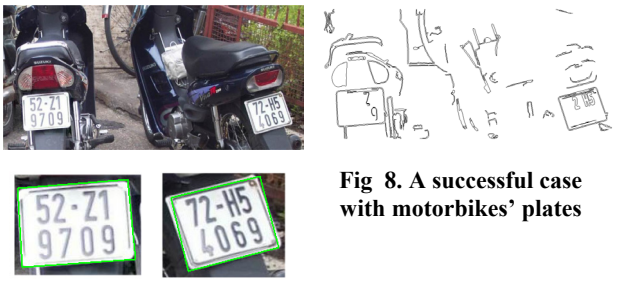


Fig 8. A successful case with motorbikes' plates

4. CONCLUSIONS AND FUTURE WORK

4.1. Conclusions

This algorithm performs well on various types of VLP images, even on scratched, scaled plate images. However, it still has a few errors when dealing with bad quality plates. If we used the more modern camera, the results would be better and we could reduce many errors of bad plates. For example, by using an infrared camera, we can obtain high quality images of plates which are not clearly seen due to mud or dust.

In summary, the combination of Hough transform and contour algorithm produces the higher accuracy and faster speed for VLP detection. This made the approach practical for real time systems. In practice, we use this algorithm in our automatic VLPs recognition system.

4.2. Future work

We are working on a number of algorithms in the preprocessing module. The purpose is to detect regions that are likely plate regions first and thus to reduce the computation cost of the VLP detection algorithm. In addition, we intend to combine a number of texture-based approachs, and machine learning methods to evaluate plate-cadidates.We believe these will improve the accuracy and the speed of the algorithm furthermore.

5. REFERENCES

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